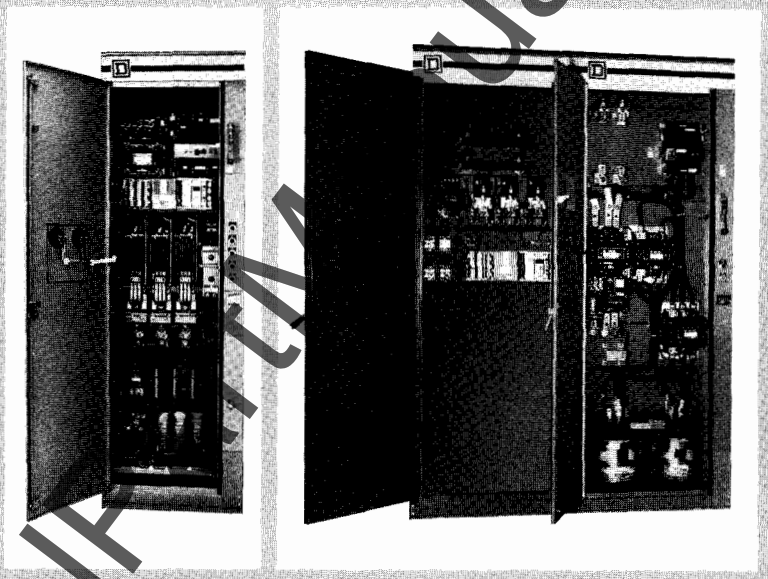


Synchronous Motor Starters

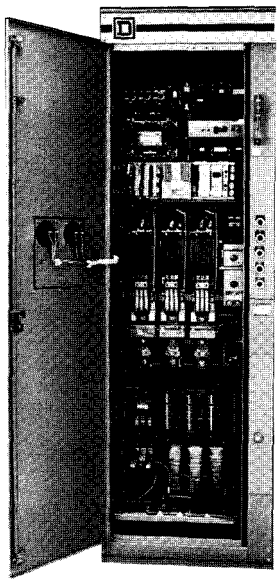
CONTENTS

SYNCHRONOUS MOTOR STARTERS

FULL VOLTAGE, NON-REVERSING

Class 8820 full voltage magnetic starters provide a simple, reliable, and automatic method of starting synchronous motors.

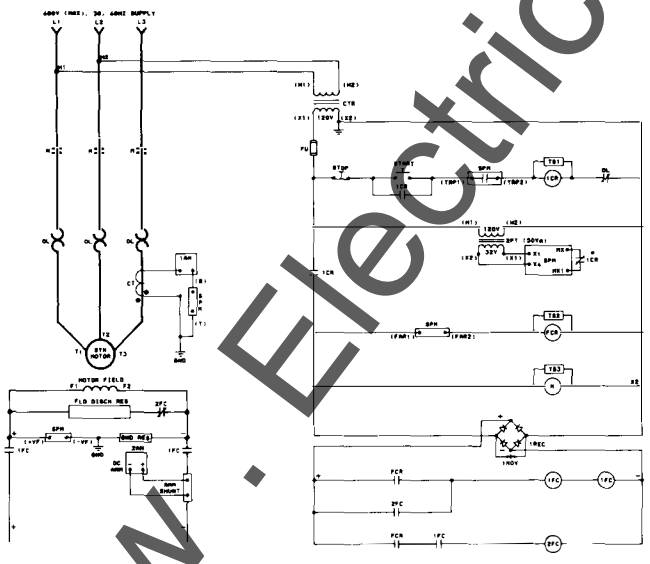
Advantages gained with synchronous control are constant speed, efficient low speed, and power factor correction. Typical applications would be for generators, alternators, compressors, grinding and pulverizing equipment.



Class 8820
Type KG-1

Starter Prices Include:

- Three pole magnetic line contactor (M)
- Control transformer with secondary fuse (CTR)
- Low voltage protection (CR)
- Three element melting alloy type thermal overload relay with hand reset (OL)
- AC ammeter
- Start-Stop push buttons
- Field control equipment consisting of:
  - DC field ammeter with shunt
  - Field discharge resistor
  - Field application contactors (1FC, 2FC)
  - Solid State synchronizing and protection panel (SPM) with the following features:
    - Pull-out protection
    - Stall protection for squirrel cage winding during both running and starting
    - Prolonged acceleration protection for squirrel cage winding
    - Loss of excitation voltage protection
    - Application of excitation voltage to field winding at exactly the proper speed and phase angle
  - Contacts for unloading motor during starting



Typical Elementary Diagram
NEMA Sizes 2 through 5

600 VOLTS MAX.									50-60 HZ
AC Volts	Max. HP		NEMA Size	General Purpose Enclosure NEMA Type 1		Outdoor Enclosure NEMA Type 3		Dusttight Enclosure NEMA Type 12	
	1.0 PF	0.8 PF		Type	Price	Type	Price	Type	Price
240	20	15	2	SDG-1	$10360.	SDW-1	$12360.	SDA-1	$11440.
	40	30	3	SEG-1	10730.	SEW-1	12730.	SEA-1	11810.
	60	50	4	SFG-1	11600.	SFW-1	13600.	SFA-1	12680.
	125	100	5	SGG-1	13502.	SGW-1	15502.	SGA-1	14586.
	250	200	6	SHG-1	17996.	SHW-1	19996.	SHA-1	19076.
	350	300	7	SJG-1	23904.	SJW-1	25904.	SJA-1	24984.
	500	450	8	KG-1	25630.	KW-1	27630.	KA-1	26710.
480	30	25	2	SDG-1	10360.	SDW-1	12360.	SDA-1	11440.
	60	50	3	SEG-1	10730.	SEW-1	12730.	SEA-1	11810.
	125	100	4	SFG-1	11600.	SFW-1	13600.	SFA-1	12680.
	250	200	5	SGG-1	13502.	SGW-1	15502.	SGA-1	14582.
	500	400	6	SHG-1	17996.	SHW-1	19996.	SHA-1	19076.
	700	600	7	SJG-1	23904.	SJW-1	25904.	SJA-1	24984.
	1000	900	8	KG-1	25630.	KW-1	27630.	KA-1	26710.

SYNCHRONOUS MOTOR STARTERS

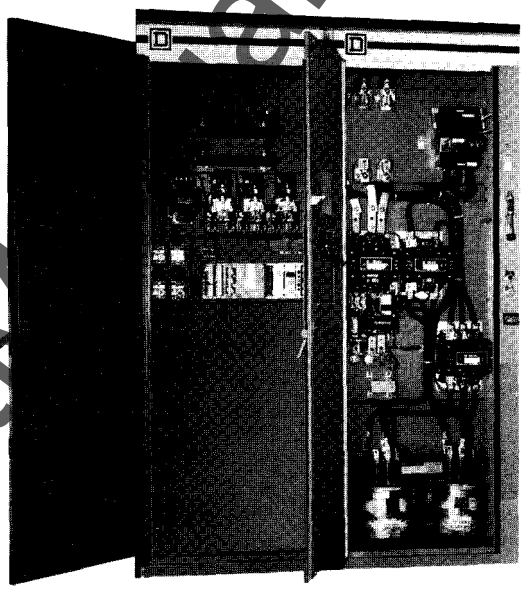
CLASS 8822

REDUCED VOLTAGE AUTOTRANSFORMER

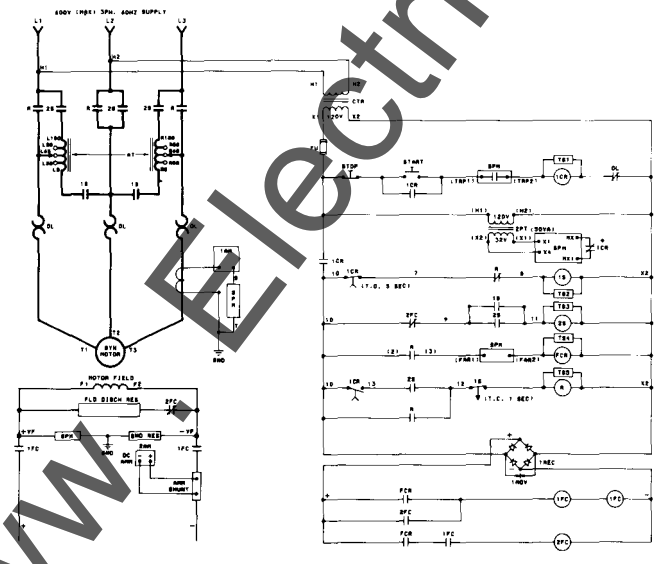
Class 8822 reduced voltage autotransformer type synchronous starters are used whenever it is necessary to limit either the motor inrush or the motor torque on starting. The automatic method of starting is the same as for Class 8820 full voltage starters and the advantages and typical applications listed also apply.

Starter Prices Include:

- Two and Three pole magnetic contactors for starting (1S & 2S)
- Three pole magnetic contactor for running (R)
- Autotransformer for starting duty
- Control transformer with secondary fuse (CTR)
- Low voltage protection (CR)
- Three element melting alloy type thermal overload relays with hand reset (0L)
- AC ammeter
- Start-Stop push buttons
- Field control equipment consisting of:
  - DC field ammeter with shunt
  - Field discharge resistor
  - Field application contactors (1FC, 2FC)
  - Solid state synchronizing and protection panel (SPM) with the following features:
    - Pull-out protection
    - Stall protection for squirrel cage winding during both running and starting
    - Prolonged acceleration protection for squirrel cage winding
    - Loss of excitation voltage protection
    - Application of excitation voltage to field winding at exactly the proper speed and phase angle
  - Contacts for unloading motor during starting



Class 8822
Type SHG-1
With Optional Circuit Breaker



Typical Elementary Diagram
NEMA Sizes 2 through 5

600 VOLTS MAX.									50-60 HZ
AC Volts	Max. HP		NEMA Size	General Purpose Enclosure NEMA Type 1		Outdoor Enclosure NEMA Type 3		Dusttight Enclosure NEMA Type 12	
	1.0 PF	0.8 PF		Type	**Price**	Type	**Price**	Type	**Price**
240	20	15	2	SDG-1	**$13180.**	SDW-1	**$16180.**	SDA-1	**$14680.**
	40	30	3	SEG-1	**14232.**	SEW-1	**17232.**	SEA-1	**15732.**
	60	50	4	SFG-1	**16702.**	SFW-1	**19702.**	SFA-1	**18202.**
	125	100	5	SGG-1	**18670.**	SGW-1	**21670.**	SGA-1	**20170.**
	250	200	6	SHG-1	**28776.**	SHW-1	**31744.**	SHA-1	**30244.**
	350	300	7	SJG-1	**42160.**	SJW-1	**45160.**	SJA-1	**43660.**
	500	450	8	KG-1	**48230.**	KW-1	**51230.**	KA-1	**49730.**
480	30	25	2	SDG-1	**13180.**	SDW-1	**16180.**	SDA-1	**14680.**
	60	50	3	SEG-1	**14402.**	SEW-1	**17402.**	SEA-1	**15902.**
	125	100	4	SFG-1	**16852.**	SFW-1	**19852.**	SFA-1	**18352.**
	250	200	5	SGG-1	**19574.**	SGW-1	**22574.**	SGA-1	**21074.**
	500	400	6	SHG-1	**29752.**	SHW-1	**32752.**	SHA-1	**31252.**
	700	600	7	SJG-1	**43370.**	SJW-1	**46370.**	SJA-1	**44870.**
	1000	900	8	KG-1	**50874.**	KW-1	**53874.**	KA-1	**52374.**

SYNCHRONOUS MOTOR STARTERS

ADDITIONS AND MODIFICATIONS

Description	Item Number	Price
ENCLOSURE MODIFICATIONS:		
Gasketing on NEMA Type 1 Enclosure Cabinet Space Heater Wired to N.C. Starter Interlock	101	$ 440.
Outline dimension fig. 3	102	280.
Outline dimension fig. 4	103	S60.
Outline dimension fig. 5	104	840.
Thermostat for Space Heater	105	252.
PILOT DEVICES:		
On-Off Selector Switch instead of Start-Stop Pushbutton	201	N/C
Hand-Off-Auto Selector Switch	202	88.
Pilot Light (Specify Color)	203	88.
Pilot Light — Push to Test (Specify Color)	204	108.

METERS AND INSTRUMENTS:	Number of Additional Transformers Required		Item Number	Price
	Potential	Current		
Transfer switch for AC Ammeter	0	2	301	408.
AC Voltmeter	0	0	302	792.
Transfer Switch for AC Voltmeter	0	0	303	408.
DC Voltmeter	0	0	304	840.
Additional Power Factor Meter (The SPM includes a power factor meter as standard. Cabinet must be opened to view meter.)	2	2	305	2240.
Wattmeter	2	2	306	2240.
Watthour Meter	2	2	307	2060.
Var meter	2	2	308	2240.
Elapsed Time Meter — Monitors Motor Running Time			309	400.
Current Transformer			310	664.
Potential Transformer			311	400.

Description	Item Number	Price
POWER CIRCUIT MODIFICATIONS:		
Main Circuit Breaker		
NEMA Size 2	401	688.
3	402	748.
4	403	1368.
5	404	2660.
6	405	3900.
7	406	5428.
8	407	9200.
Addition of Fuse Clip Assembly for Current Limiting Fuses (Does not include fuses)	408	400.
CONTROL CIRCUIT MODIFICATIONS:		
Substitute 2KVA control Power Transformer for Standard	501	S44.
Additional Electrical Interlocks (N.O. or N.C.)	502	100.
AUXILIARY AND PROTECTIVE RELAYS:		
Time Delay Undervoltage Protection	601	440.
Phase Reversal — Open Phase Protection (Add current transformer for starters size 5 and smaller. See item 310)	602	1720.
Ground Fault Protection for Grounded System (Includes Ground Fault Relay, Current Transformer and Indicating Lights)	603	2120.
Ground Fault Detection and Protection for ungrounded System (Includes Potential Transformers, Indicating Lights, Resistors and voltage sensing relays)	604	4612.
Control Relay (600V contacts)	605	240.
AUXILIARY AND PROTECTIVE RELAYS (cont'd)		
Pneumatic Time Delay Relay	606	320.
Motor Driven Time Delay Relay	607	704.
FIELD EXCITATION EQUIPMENT:		
Motor Field Resistor — If an existing source is supplying direct current at a fixed voltage to the motor field, the motor field excitation can be adjusted by means of a resistor with adjustable taps connected in series with the motor field. Select resistor from table below based on the motor maximum field current. If the field current falls between two values use the next higher rating. Prices are based on resistance required to produce a reduction in applied field voltage to 70% of nominal.		
Motor Field Current (DC Amperes)		
10	701	440.
15	702	500.
20	703	S60.
25	704	620.
30	705	700.
40	706	800.
50	707	900.
60	708	1000.
70	709	1100.
Motor Field Rheostat — Similar to motor field resistor except adjustable from outside of cabinet by through the door knob. Select from table below based on motor maximum Field Current. Rheostat also provides adjustment to 70% of nominal field voltage.		
Motor Field Current DC Amperes		
10	710	1000.
15	711	1000.
20	712	1804.
25	713	1804.
30	714	1804.
40	715	2631.
50	716	3539.
60	717	3539.
70	718	3539.
Exciter Field Rheostat — If a separate Motor — Generator (M-G) Set is used, an exciter field rheostat can be used to adjust the generator output voltage.		
Drilling for Customer Rheostat	719	200.
Mounting and Wiring of Customer's Rheostat	720	400.
Rheostat Supplied Mounted and Wired	721	1000.
(Maximum exciter Field Current 4.5A)		
Static Exciter — The static exciter package provides AC to DC power conversion for individual synchronous motor field excitation. Taps are provided for output voltage adjustment. Select KW rating from table below based on the following formula:		
$KW = (V_F \times I_F \times 1.15)/1000$		
WHERE: V_F = Motor Field Voltage (125V or 250V)		
I_F = Motor Field Current		
If required KW falls between two values select next higher rating.		
3.0 KW	772	6426.
4.5 KW	723	6816.
6.5 KW	724	7408.
9.0 KW	725	7992.
13.0 KW	726	9220.

SYNCHRONOUS MOTOR STARTERS

CLASS 8820 8822

BASIC SYNCHRONOUS STARTER REQUIREMENT

A synchronous motor is a constant speed motor that is started as a squirrel cage motor (by means of cage bars built into the rotor) and then locked into synchronism by direct current applied to the field (rotor) winding. When running in synchronism, the rotor is locked in step with the stator rotating field. In other words, there is no slip as is the case in induction motors.

A synchronous motor starter such as the Class 8820 and Class 8822 must be able to perform several functions in order to get the motor started and protect it from damage. These are described as follows:

1. Energize the Stator — This can be done by methods normally used with squirrel cage motors. A full voltage (Class 8820) or reduced voltage, auto-transformer (Class 8822) starter can be used. Standard thermal overload protection is utilized.
2. Protect the Squirrel Cage Bars — Synchronous motors take advantage of the fact that the Squirrel cage bars are used for starting only and can therefore be sized smaller than would normally be required for an induction motor. This results in the saving of valuable space which is needed for the field winding. This means that the squirrel cage bars must be duty cycle rated and the starter must provide a means of detecting time that the motor operates on the squirrel cage bars and remove power before damage occurs. Class 8820 and 8822 starters use a Solid State Synchronizing and Protection Module (SPM).
3. Provide a Field Discharge Path — During the time that a synchronous motor is accelerating to synchronous speed, an ac voltage is induced into the field winding. This is called the induced field voltage. If the field were left open circuited during starting, the induced field voltage would increase to very high amplitudes that could damage the field winding insulation. For that reason, all synchronous motor starters, including the Class 8820 and 8822 must ensure that a field discharge path is provided. This normally takes the form of a field discharge resistor. Ohmic value of the field discharge resistor is fairly critical and is normally recommended by the motor manufacturer.
4. Energize Field Winding — DC voltage must be applied to the motor field in order to cause the motor to synchronize. This dc field voltage must be applied after the motor has reached approximately 95% of full speed and when the stator rotating field and the rotor are properly aligned. Detecting proper speed and proper rotor-stator alignment is a function of the SPM. Application of dc voltage is accomplished by the field contactor.
5. Provide Pull-Out Protection — Once the motor is running in synchronism, loss of (or low) field excitation or mechanical overload can cause the motor to pull out of synchronism and run as an induction motor. For reasons stated above under squirrel cage protection, this condition cannot be tolerated for any length of time. A synchronous motor starter must detect pull-out, immediately reestablish the field discharge path and remove dc voltage from the field. The starter can then remove power from the motor or a short time delay can be introduced to allow the motor a chance to pull back into synchronism. In the Class 8820 and 8822 synchronous motor starters, pull-out is detected by the SPM.

PROTECTIVE FUNCTIONS

Type of Protection	Protective Device	Description
Mechanical Overload (STANDARD)	Thermal Overload (OL)	Protects motor stator winding from damage due to excessive temperature rise caused by higher than normal full load current.
Prolonged Acceleration Time Or Stalled Rotor (STANDARD)	Synchronizing And Protection Module (SPM)	Protects motor squirrel cage winding from damage due to excessive temperature rise caused by inability of the motor to accelerate in specified time period.
Pull Out Protection (STANDARD)	Synchronizing And Protection Module (SPM)	Protects motor squirrel cage winding from thermal damage caused by inability of the motor to maintain synchronization. Also protects motor and load from damaging torque pulsations caused by running out of synchronization with field power applied.
Lagging Power Factor (STANDARD)	Synchronizing And Protection Module (SPM)	Detects Loss of Synchronization due to excessive load on motor or Low Field Excitation
Loss of Field Voltage (STANDARD)	Synchronizing And Protection Module (SPM)	Loss of Field Voltage or Low Field Voltage results in Pull out or lagging power factor
Loss of Field Current (OPTIONAL)		The SPM will protect against loss of field current caused by problems with the motor field supply. The SPM will not detect loss of field current due to motor problem such as field winding or brush failure. A separate field loss relay is required.
High Induced Field Voltage (STANDARD)	Field Discharge Resistor	Protects the field winding insulation from damage due to excessively high induced field voltage during starting. The value of resistance is a function of motor design and must be specified by the motor manufacturer.

SYNCHRONOUS MOTOR STARTERS

ENCLOSED CONTACTOR RATINGS

NEMA SIZE†	2	3	4	5	6	7	8
Continuous Current Rating	45	90	135	270	540	810	1215

† Class 8822 starters use 1 NEMA size smaller for start contactors 1S and 2S.

Control Voltage

120VAC control power provided by internal control power transformer with fused secondary.

Autotransformers (Class 8822 only) 50% - 65% - 80% taps are provided. Autotransformers have duty cycle ratings in accordance with NEMA ICS2-214 (Medium Duty)

STANDARD FIELD COMPONENTS

Field Contactor (FC)—The field contactor is the device that completes the field circuit through the field discharge resistor during starting and applies the dc power to the field to pull the motor in to synchronism. Operation of the field contactor is controlled by the SPM. The field contactor consists of 3 separate single pole contactors with two being normally open mechanically tied together with coils in series (1FC) and one being normally closed (2FC). Sequencing of the contactors is controlled so that there is a positive overlap between the normally open and closed contacts.

Synchronizing And Protection Module (SPM)—The SPM is an electronic device which monitors motor operation during starting and running. The SPM controls the operation of the field contactor so that dc power is applied to the motor field at the proper time. The SPM also provides protective features as described elsewhere in this catalog. As an additional feature, the SPM includes a power factor meter which monitors the motor power factor.

Field Discharge Resistor—The field discharge resistor is selected based upon the recommendations of the motor manufacturer so that voltage induced into the field winding during starting and stopping does not exceed the rating of the insulation. The value of field discharge resistor also affects the starting torque which the motor can produce. The field discharge resistor is switched into and out of the motor field circuit by the normally closed field contactor pole (2FC).

DC Ammeter And Shunt—The dc ammeter and shunt are used to measure the dc field current when the normally open field contactor poles (1FC) are closed and the motor is running in synchronism.

OPTIONAL FIELD EXCITATION EQUIPMENT

The operation of a synchronous motor requires a source of dc voltage to excite the rotor field coils of the motor. This supply of dc voltage can be obtained from any one of the following:

1. Plant source which supplies a fixed voltage to plant equipment. Adjustment of the field excitation voltage can be accomplished by use of a motor field resistor with adjustable taps, see modifications 701 through 709, or a motor field rheostat, see modifications 710 through 718.
2. Separate motor-generator (M-G) set commonly called an exciter. The M-G set supplies dc to the motor field. The output voltage of the M-G set and consequently the motor field voltage can be adjusted by means of an exciter field rheostat. See modifications 719 through 721. Also see Figure 1. Occasionally a small starter is required to control the M-G set motor.
3. Generator either belt or direct driven by the synchronous motor itself. The operation is similar to that of item 2 above.
4. Static exciter which converts three phase ac at line voltage to 125V dc or 250V dc as required by the motor field. Voltage adjustment available with transformer taps normally eliminates the need for a motor field rheostat. Voltage adjustments are available as follows:

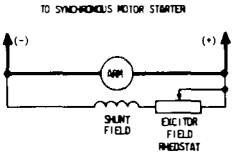
   Transformer Primary — 5% taps above and below nominal input voltage.

   Transformer Secondary — 7 taps in 5 volt increments below nominal output voltage.

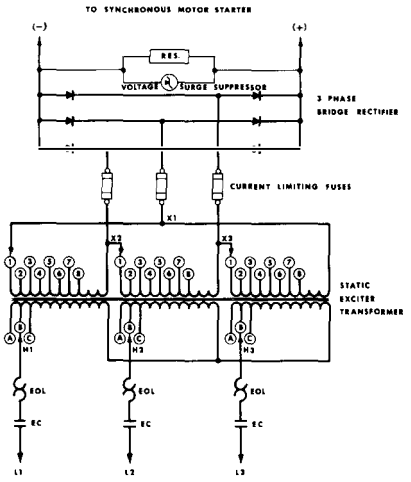
The static exciter consists of:

Dry type rectifier transformer
Three phase full wave silicon rectifier bridge
Surge protection for silicon rectifiers
Current limiting fuses for rectifier protection
Magnetic contactor with overloads to protect against overload conditions.

See Figure 2 and Modifications 722 through 726.



Motor Generator Set
Figure 1



Static Exciter
Figure 2

SYNCHRONOUS MOTOR STARTERS

CLASS 8820 8822

ORDERING INFORMATION

A. STARTER DATA
   1. Class and Type
   2. Additions and Modifications by item number.

B. MOTOR DATA
   1. Horsepower, line voltage, frequency, power factor, full load current, locked rotor current.
   2. Rated field voltage.
   3. Rated field current.
   4. Maximum field current.
   5. Field Resistance.
   *6. Induced field current at zero speed with full voltage applied to the stator.
   *7. Maximum allowable stall time without injury to squirrel cage winding.
   *8. Recommended ohmic value of field discharge resistor.
   9. Source of dc excitation for motor field, (shop supply, motor-generator (M-G) set, generator driven by the synchronous motor, or static exciter.)

C. LOAD DATA
   1. Time required for acceleration of motor and load from zero speed to synchronous speed.

* Items #6, 7, 8 above are normally not on the motor nameplate and therefore may be difficult to obtain. Inability of customer to provide all required motor data will require start-up service by a factory service engineer at the rate in effect at the time service is performed plus travel and living expenses.

CLASS 8820

	Without Circuit Breaker			With Circuit Breaker		
		Weight			Weight	
Type	Figure	LBS	KGS	Figure	LBS.	KGS.
SDG-1		220	100		255	116
SDW-1	3	270	122	3	305	138
SDA-1		245	111		280	127
SEG-1		270	122		305	138
SEW-1	3	310	140	3	345	156
SEA-1		290	131		325	147
SFG-1		330	150		365	165
SFW-1	3	370	168	3	405	184
SFA-1		345	156		380	172
SGG-1		425	192		460	209
SGW-1	3	470	213	3	505	229
SGA-1		435	197		470	213
SHG-1		580	263		615	279
SHW-1	3	620	281	3	655	297
SHA-1		600	272		635	288
SJG-1		860	390		910	413
SJW-1	3	940	426	4	990	449
SJA-1		930	422		980	444
KG-1		940	426		990	449
KW-1	3	960	435	4	1010	458
KA-1		890	404		1000	455

CLASS 8822

	Without Circuit Breaker			With Circuit Breaker		
		Weight			Weight	
Type	Figure	LBS	KGS	Figure	LBS.	KGS.
SDG-1		470	213		505	229
SDW-1	3	535	243	3	570	259
SDA-1		485	220		520	236
SEG-1		550	249		585	265
SEW-1	3	610	277	3	645	292
SEA-1		560	254		595	270
SFG-1		840	381		875	397
SFW-1	3	920	417	3	955	433
SFA-1		860	390		895	406
SGG-1		1170	531		1205	547
SGW-1	4	1270	576	4	1305	592
SGA-1		1220	553		1255	569
SHG-1		1470	667		1540	698
SHW-1	4	1640	744	4	1675	760
SHA-1		1570	712		1605	728
SJG-1		2170	984		2220	1006
SJW-1	5	2370	1075	5	2420	1098
SJA-1		2270	1030		2320	1052
KG-1		2670	1211		2720	1233
KW-1	5	2870	1302	5	2920	1324
KA-1		2770	1256		2820	1279

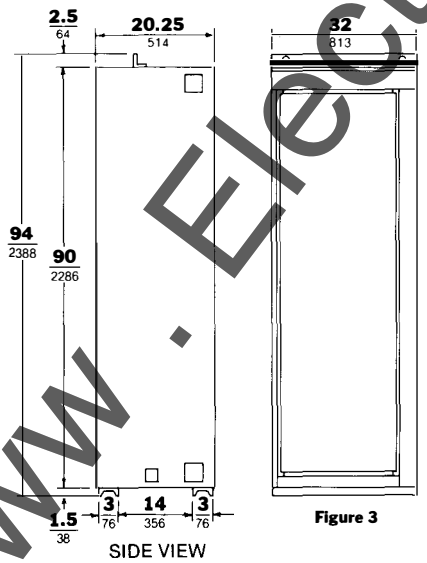


Figure 3

Figure 4

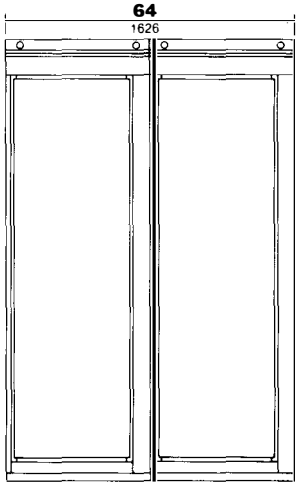
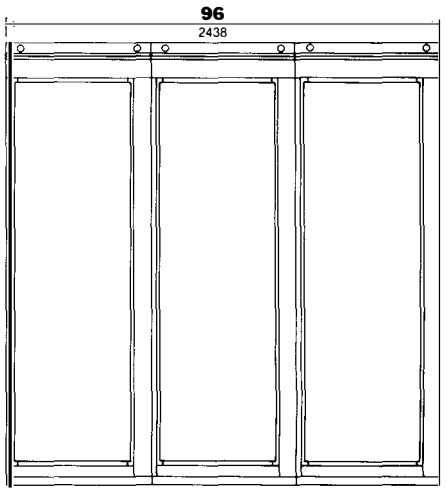


Figure 5



Dual Dimensions: INCHES / Millimeters

SQUARE D COMPANY

1/81 CS Printed in U.S.A.